rise to stereopsis. It is stereopsis which inevitably occurs and dominates over other processes to which the perception of symmetry belongs. It is an interesting paradox that when the symmetric and nonsymmetric displays are uncorrelated (by turning one through 90°), binocular rivalry results. One might expect for this case the largest masking of the symmetric pattern by the competing uncorrelated noise; the opposite is in fact the case, since during binocular rivalry the symmetric pattern is quite often visible as dominance alternates.

This binocular disappearance of monocularly seen symmetrical shapes sharpens the implications of the original demonstration (*1*). These demonstrated that binocular shapes can be perceived from random, shapeless images and indicated that binocular combination of monocular images *can* occur prior to the recognition of form. The phenomenon described here has a further implication. It suggests that whenever binocular combination occurs, this process *precedes* or *dominates* the recognition of bilateral symmetry. This result can be interpreted in the light of some neurophysiological findings in the cat (*3*). Even at the input layers of the striate cortex binocular neural units exist in abundance. There are also monocular units and binocular units of monocular dominance. The reported psychological phenomenon suggests that some monocular neural units might be inoperative when the two monocular images can be fused without binocular rivalry. In this demonstration bilateral symmetry was selected as an instructive example only, and the reported technique obviously can be applied to monocular shapes in general.

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1. B. Julesz, *Bell System Tech. J.* **39**, 1125 (1960); *Science* **145**, 356 (1964).
2. The unusual practice of omitting references to experimental statistics was intentional. The reported findings were obtained originally from 20 subjects with identical responses. Subsequently, the phenomeon was demonstrated on six different occasions to large groups of experimental psychologists, physicians, television engineers, architects, and artists, in excess of 500 total, who confirmed the findings. In cases of such universal phenomena, in my opinion references to number of subjects distort the generality of the results.
3. D. H. Hubel and T. N. Wiesel, *J. Physiol.* London **160**, 106 (1962).
4. I thank Ellen Gritz for developing the computer program which generated the displays and R. A. Payne for producing them in vectograph format.

6 April 1966

Memory Transfer

Learned behavior has been reported to be transferred as a result of injecting RNA-containing fractions from the brains of trained rats (donors) into untrained rats (recipients).

Such a result is of potential importance for the understanding of the mechanisms of learning and memory. We summarize here our separate attempts to reproduce the results reported (*1*). Each of the sets of experiments was independently undertaken in one of our laboratories; the unanimity of our results became apparent only in the course of subsequent informal discussions. We all found that the reported transfer of training due to transfer of RNA was not, in our laboratories at least, a demonstrable phenomenon.

Our general procedures may be summarized as follows. *Extraction*: In all experiments we used the phenol extraction procedure described (*1*). There were, however, some minor procedural variations on this method in different experiments. *Injection*: In some experiments recipients received the extract from the brain of a single donor. In others pooled brains were used for extraction and each recipient was given a portion of this extract. Injections were intraperitoneal except in a few instances in which the intracisternal route was used. *Training*: In different experiments donors were given one of the following kinds of initial training. (i) Acquisition of an approach response like that described (*1*); we also evaluated the effects of several variations of this technique that were designed to increase its sensitivity. (ii) Learning of a brightness discrimination in a T-maze (food reward). (iii) Learning of a complex maze problem (food reward). (iv) Conditioning of an emotional response (CER). In these experiments a stimulus was paired with a brief, inescapable electric shock; fear conditioning was measured in terms of the subsequent suppression of ongoing behavior (lever-pressing or consummatory behavior) in the presence of the stimulus alone. (v) Learning of a discrimination problem; this experiment was an attempt to replicate an earlier report of positive transfer (*2*).

In 18 experiments no clear evidence of a transfer of any of these kinds of training from trained donors to recipients was found. The detailed reports from all of our laboratories have been compiled and are available for examination (*3, 4*).

Our data extend and amplify those reported by Gross and Carey, by Luttges *et al.*, and by Gordon *et al.* (*5*). It is true that a negative result, indicative of "no difference," is easy to come by in any experiment. But it is also true that a positive result should have demonstrable replicability and generality. Unfortunately, the data bearing on both generality and replicability appear to be on the negative side.

Our consistently negative findings do not, of course, bear directly on the possibility that RNA may be involved in the mechanism of memory. They indicate only that results obtained with one method of evaluating this possibility are not uniformly positive. Furthermore, we feel that it would be unfortunate if these negative findings were to be taken as a signal for abandoning the pursuit of a result of enormous potential significance. This is especially so in the light of several other related but not identical experiments (*6*) that support the possibility of transfer of learning by injection of brain-extract from trained donors. Failure to reproduce results is not, after all, unusual in the early phase of research when all relevant variables are as yet unspecified (see *7*).

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2. A. L. Jacobson, F. R. Babich, S. Bubash, C. Goren, *Psychonomic Sci.* **4**, 3 (1966).
3. Copies of detailed reports of all experiments may be obtained from Peter L. Carlton, Graduate Psychology Laboratories, Rutgers University, New Brunswick, New Jersey. Funds for duplication and mailing of these reports have been made available by Rutgers University.
4. Material supplementary to this paper has been deposited as Document No. 8990 with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington, D.C. 20025. A copy may be secured by citing the Document number and by remitting $12.50 for photoprints, or $4.25 for 35-mm microfilm. Advance payment is required. Make checks or money orders payable to Chief, Photoduplication Service, Library of Congress.
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2 June 1966

Antigen-RNA Complexes

Hashem (*1*) reports studies which suggest that ribosomal RNA extracted from human lymphocytes previously incubated with specific sensitizing antigens will induce cytological transformation and mitoses in cultured autologous lymphocytes. Hashem's conclusions are based essentially on an enumeration of the percentage of transformed cells and mitoses appearing in the cultures; the prevention of mitoses by treating the active RNA fractions with ribonuclease; and the lack of transformation in cultures incubated with RNA extracted from autologous nonstimulated lymphocytes. The cells were grown in minimum-essential medium supplemented with 15 percent fetal calf serum and antibiotics (penicillin and streptomycin); results were considered positive if after 5 days of culture there were more than 3 percent transformed cells and over 0.1 percent mitoses.

We are not told the specific percentage of transformation obtained in each culture or the range of transformation obtained with each antigen and with the RNA from antigenically stimulated cells. It is therefore impossible to compare the efficacy of RNA as a blastogenic agent with the antigen from which it presumably derived its transforming properties. Furthermore, it is difficult to evaluate the significance of 3 percent transformation in view of the reports from several laboratories that far greater transformation may occur in the absence of phytohemagglutinin or specific antigens. Johnson and Russell (*2*) noted 5 to 48 percent transformation in cultures of human peripheral lymphocytes grown with media supplemented with fetal calf serum. I have observed 5 to 40 percent transformation in a similar culture system (*3*) and Hirschhorn *et al.* (*4*), report 5 to 10 percent blastoid cells in their control cultures grown with fetal calf serum.

Johnson and Russell reduced the degree of transformation by substituting autologous for fetal calf serum. Elimination of penicillin and streptomycin from the medium resulted in further reduction, an indication that the cells may have been responding to several components of the culture medium. Johnson and Russell obtained between 1.9 and 5.3 percent transformed cells even when they used autologous human serum and eliminated antibiotics.

Hashem reports that ribonuclease completely abolished the mitosis-stimulating activity of RNA, but makes no statement concerning its effect on the lymphocyte-transforming properties of the active RNA preparations. Friedman and co-workers (*5*), who induced antibody formation in rat lymph node cultures with RNA extracted from macrophages incubated previously with bacteriophage T2, found that ribonuclease reduced but did not completely abolish the ability of RNA to induce antibody synthesis. Thus the transforming properties attributed by Hashem to RNA may actually be due to specific sensitizing antigens which have formed complexes with the active RNA fractions.

Friedman and co-workers have convincingly demonstrated that several antigens of phage T2 are present in those RNA preparations which are capable of inducing antibody synthesis, and they also speculate that this activity is specifically due to the presence of these antigens.

That macrophages may also be important in peripheral lymphocyte transformation is evident from the work of McFarland and Heilman (*6*). Starting with peripheral blood, partially purified of polymorphonuclear leukocytes, they observed the gradual appearance of macrophages, each of which became surrounded by clusters of small lymphocytes. These cells firmly attached themselves to the central macrophage and subsequently underwent blastoid transformation. The authors speculate that such a contact, if accompanied by a cytoplasmic connection, could provide a means of transfer of instructive material needed for transformation or antibody synthesis. Hashem also observed occasional cytoplasmic connections between small lymphocytes and transforming cells. Although macrophages are not specifically mentioned in Hashem's report, in view of the observations of McFarland and Heilman (*6*) and the importance of macrophages in the induction of primary immune responses in vitro (*5*, *7*) it seems possible that at least some of the RNA capable of inducing transformation may have been extracted from macrophages which had previously encountered the specific antigen.

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30 March 1966